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May 28, 1992

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Subject. **Beaver Valley Power Station, Unit No. 2**
Docket No. 50-412, License No. NPF-73
Turbine Valve Surveillance Testing (TAC M77640)

Ref: 1) Letter from A. W. De Agazio (Nuclear Regulatory Commission) to J.D. Sieber (Duquesne Light Company), dated June 28, 1991. Subject - Request for Additional Information

Ref: 2) Letter from J. D. Sieber (Duquesne Light Company) to the NRC, dated October 1, 1990. Subject - Proposed Operating License Change Request No. 16

This letter provides a response to the NRC Request for Additional Information (RAI) forwarded by Reference 1. Based on the attached Westinghouse report it has been determined that, with an eighteen (18) month reheat stop and intercept valve test interval, the total turbine missile generation probability for Beaver Valley Power Station Unit 2 meets the appropriate turbine system reliability criteria.

Our proposed technical specification revision, submitted by Reference 2, will be revised to propose a reheat stop and intercept valve test interval of 18 months. The revised submittal will be forwarded in the near future.

In response to the concerns raised by the Salem turbine overspeed event, as described in Information Notice 91-83, a surveillance program is being developed to functionally verify the operability of each turbine trip solenoid valve on a refueling frequency. This program along with turbine surveillance tests and inspections will ensure the turbine overspeed protection system is maintained and operated consistent with the assumptions used in the attached evaluation.

Should you have any questions regarding this response, please contact Mr. Ken McMullen at (412) 393-5214.

Sincerely,

George S Thomas for
J. D. Sieber

cc: Mr. L. W. Rossbach, Sr. Resident Inspector
Mr. T. T. Martin, NRC Region I Administrator
Mr. A. W. De Agazio, Project Manager
Mr. M. L. Bowling (VEPCO)

REQUEST FOR ADDITIONAL INFORMATION

TURBINE REHEAT STOP AND INTERCEPT VALVE TESTING

Request

1. Please submit information relating to the probabilities for missile ejection over the entire spectrum of overspeed conditions.

Response

Based on the Westinghouse evaluation (documented in the attached report), it has been determined that with an eighteen (18) month reheat stop and intercept valve test interval, the total turbine missile generation probability for Beaver Valley Power Station Unit 2 meets applicable acceptance criteria.

Three overspeed events were considered in evaluating the probability for missile ejection: design overspeed (120 percent of rated speed), intermediate overspeed (132 percent of rated speed), and destructive overspeed (speeds greater than 170 percent of rated speed). The Westinghouse evaluation focused on the design and intermediate overspeed events since they would be affected by the test intervals of the reheat stop valves and intercept valves. The destructive overspeed event does not result fror failures of reheat stop and intercept valves and therefore was excluded from further consideration.

Table 2 of the Westinghouse report presents the total probability of turbine missile ejection for the design and intermediate overspeed events given that system separation occurs. The total probability is based on conditional probabilities of missile ejection for Unit 1 given that design or intermediate overspeed occurs. Unit 1 conditional probabilities are more conservative than values calculated for Unit 2.

The total probabilities for a missile ejection must be multiplied by the average annual frequency of system separation for the Unit so that they can be measured against acceptance criteria. Based on a review of Unit 2 plant trips, the average annual frequency of system separation was calculated to be 0.22 (one occurrence in four and one-half years). To provide additional conservatism, the average annual frequency of system separation was assumed to be one-half (0.5).

The Westinghouse report did not consider destructive overspeed probability. Therefore, the "general" acceptance criteria of 1×10^{-5} per year for turbine missile ejection from an unfavorably oriented turbine was reduced. A ten (10) percent fraction of the "general" acceptance criteria was assumed as the acceptance criteria for the design and intermediate overspeed missile probabilities evaluated. This leaves an adequate reserve margin of 90 percent of the acceptance criteria for other significant overspeed events such as destructive overspeed.

The product of the average annual frequency of turbine separation for Unit 2 (conservatively assumed to be 0.5) and the total probability of turbine missile ejection (6.79×10^{-7}) is less than the acceptance criteria of 1×10^{-6}. Thus, the turbine system reliability is acceptable with an eighteen (18) month test interval for reheat stop and intercept valves.

Request

2. Provide a discussion of the available data relating to testing the subject valves that could justify DLC's conclusion regarding the reliability of the overspeed protection system.

Response

During the operating life of Beaver Valley Power Station Unit 1 and Unit 2 there has not been a single incidence of unplanned turbine overspeed nor a single turbine reheat stop or intercept valve malfunction that could have lead to a turbine overspeed condition.

The Unit 1 reheat stop and intercept valves were tested during Unit start-ups and monthly thereafter until 1987. The monthly testing at Unit 1 was discontinued in 1987 when it was found to be causing moisture separator reheater damage. Since 1980 the Unit 1 reheat stop and intercept valves have undergone 31 operational surveillance tests (OST 1.26.1).

The Unit 2 reheat stop and intercept valves have been tested during Unit start-ups and monthly thereafter. Since the inception of operation in November of 1987, the Unit 2 reheat stop and intercept valves have been tested at least 43 times (per OST 2.26.1) and continue to be tested on a monthly frequency.

Problems were encountered during performance of 12 of the 31 surveillance tests at Unit 1. In these instances a limit or permissive switch associated with the test circuitry required adjustment or repair. These adjustments and repairs only affected the test circuitry and did not represent a possibility for turbine overspeed since subsequent tests or plant trips showed that the valves operated as designed. The other nineteen (19) of the 31 surveillance tests were completed satisfactorily with no problems. In addition, the valves operated properly on 10 plant trips (closing on the turbine trip and opening on the subsequent plant start-up).

Each of the 43 operational surveillance tests performed at Unit 2 were completed satisfactorily. That is, full reheat stop and intercept valve strokes were verified.

Minor problems were encountered during performance of 16 of the 43 surveillance tests at Unit 2. These problems typically involved a test push-button or valve position indication. In each case the problems would not have prevented the reheat stop and intercept valves from closing in the event of a turbine trip.

The Beaver Valley data regarding reheat stop and intercept valve testing discussed above along with the attached probability analysis (based on the Westinghouse program for tracking turbine valve failure rates) provides evidence that the reheat stop and intercept valves are reliable.

Request

3. Timely detection and correction of any problem (e.g., mechanical problem) that may arise in the main steam turbine system, including the subject valves, is vital because of the potential for serious adverse consequences. Please address the plant-specific aspects of this concern as it relates to the proposed deletion of surveillance tests for the subject valves.

Response

A proposed revision to the technical specifications will be submitted to change the requested reheat stop and intercept valve test interval to an 18 month frequency. The 18 month test interval is adequate to identify and correct mechanical problems based on the favorable probability analysis described in response to Item 1 above, and the favorable valve test experience described in response to Item 2 above. In addition, the turbine is inspected periodically as described in Updated Final Safety Analysis Report Section 10.2.3.5.

Request

4. Frequent testing of the subject valves at Unit 1 is not required by the technical specifications, but DLC does perform testing prior to start-up. However, DLC asserts that even these relatively infrequent tests have caused extensive damage. In view of this experience, please explain how DLC expects to avoid such damage to Unit 2 since DLC has committed to verify proper operation of the subject valves during each plant start up as is done at Unit 1.

Response

The damage described at Unit 1 resulted from testing conducted during power operation. During testing of an intercept/stop valve, closure of the valve results in the shut-off of cycle steam flow to one (1) moisture separator reheater (MSR) and diversion of flow mostly to the opposite side MSR. When this testing is conducted at power, significantly higher shell side (cycle steam) velocity (flow) rates and corresponding pressure drops occur. These pressure drops can cause high stress levels in the shell side closure plates. At the same time, the heat transfer across the three (3) active tube bundles is increased due to higher shell side flow and this causes additional reheat steam to be cooled in the tubes resulting in larger tube side pressure drops. The cumulative effects from a series of intercept/stop valve tests performed at power are considered the primary cause of the shell side closure plate damage.

Tests conducted during start-up demonstrate that valve stem sticking is not occurring, and the tests are performed at lower flow rates which result in lower pressure drops and stress levels that are not as likely to cause MSR damage.

CALCULATION OF TURBINE MISSILE EJECTION PROBABILITY RESULTING FROM EXTENDING THE TEST INTERVALS OF INTERCEPTOR AND REHEAT STOP VALVES AT BEAVER VALLEY UNITS 1 AND 2

prepared: April 11, 1992

A calculation of the effects of extending the test intervals of the turbine interceptor and reheat stop valves at Beaver Valley Units 1 and 2 was performed using fault tree models and methodology from the Westinghouse report WCAP-11525, "Probabilistic Evaluation of Reduction in Turbine Valve Test Frequency," dated June 1987. The calculation considered the probabilities of turbine missile ejection due to overspeed. The evaluation focused on two of the three overspeed events defined in WCAP-11525 that would be affected by the test intervals of the reheat stop valves (RSVs) and interceptor valves (IVs); design and intermediate overspeed. The third overspeed event in WCAP-11525, destructive overspeed, does not result from failures of RSVs and IVs and was not included in the calculation.

Design overspeed is considered to be an overspeed of 120 percent of rated speed and results from the following failure sequence:

1. System separation (total loss of load) occurs. (This event is not modeled or accounted for in the analysis. Its frequency should be determined by Duquesne Light Co. before applying acceptance criteria.)

2. One or more governor (control) valves or two or more IVs stick open, or the initial protective action of dumping the governor and interceptor valve emergency trip fluid header fails upon loss of load or upon reaching the setpoint of the overspeed protection control system.

3. Stop and reheat stop valves close successfully after reaching the overspeed trip setpoint.

Intermediate overspeed is considered to be an overspeed of 132 percent of rated speed and results from the following failure sequence:

1. System separation occurs.

2. One or more combinations of RSVs and IVs (in the same steam path) stick open or fail to close.

3. Stop valves close successfully after reaching the overspeed trip setpoint.

Because the stop valves or governor valves must close to limit the overspeed and prevent destructive overspeed, the mechanical overspeed trip function and dump of the autostop oil system is assumed to be successful. Therefore, failures of the components of mechanical overspeed trip, including the interface valve and 20/AST solenoid valve which dump the emergency trip fluid, were not modeled in the fault trees. Referring to item 2 of the design overspeed event, failure of the overspeed protection control (OPC) system and related solenoid valves, and failure of the 20/AST solenoid valve which dumps the autostop oil upon loss of load were considered in the analysis of design overspeed.

Three test intervals of the RSVs and IVs were considered; 3 months, 12 months, and 18 months. Test intervals of the OPC solenoid valves and 20/AST solenoid valve were assumed to be 18 months in order to provide a bounding estimate of the failure probability of these valves. The failure rates of key components of the analysis are given in Table 1.

Turbine overspeed probability results are given in Table 1. Design overspeed is minimally affected by the extension of the IV and RSV test intervals because the overspeed is dominated by the failure of the control valves. This dominance is shown in Table 3. Intermediate overspeed probability increases significantly with the extension of the IV and RSV test interval. However, the products of intermediate overspeed probability and conditional probability of missile ejection, using the data from Table 2, are all small numbers.

The probabilities of turbine missile ejection are calculated in Table 2. These probabilities can be multiplied by the average annual frequency of system separation for the Beaver Valley Units so that they can be measured against acceptance criteria. The frequency of system separation typically ranges from 0.1 to 1.0 per year for plants that are equipped with reverse power relay systems. These systems delay the trip of the generator following a trip of the turbine for approximately 30 seconds or until there is adequate assurance that overspeed will not occur following a turbine trip which occurs prior to generator trip.

The acceptance criteria in WCAP-11525 was applied to a "total" probability of turbine missile ejection which summed the turbine missile probabilities for all known overspeed events. The analysis for Beaver Valley did not consider destructive overspeed probability or other possible causes of overspeed such as reverse steam flow through failed extraction non-return valves. Therefore the "general" acceptance criteria of 1.0E-05 per year for turbine missile ejection from an unfavorably oriented turbine would not be applicable. However, it would be reasonable to allocate a fraction of the "general" acceptance criteria (5 to 10 percent, for example, but no more than 25 percent) for the design and intermediate overspeed missile probabilities evaluated herein. This would leave an adequate reserve margin of 75 to 95 percent of the acceptance criteria for other significant overspeed events such as destructive overspeed.

TABLE 1 Turbine Overspeed Probabilities as Function of Interceptor Valve (IV) and Reheat Stop Valve (RSV) Test Interval		
IV & RSV Test Interval	**P(A)**	**P(B)**
3 MO	1.12E-02	1.24E-06
12 MO	1.14E-02	9.81E-06
18 MO	1.15E-02	1.96E-05

Notes:

- P(A) Probability of design overspeed (120% overspeed) given that system separation occurs.
- P(B) Probability of intermediate overspeed (132% overspeed) given that system separation occurs.

KEY DATA		
Component Failure Mode	**Failure Rate** (1/hr)	**Basis** (See Notes Below)
Interceptor valve sticks open	2.91E-07	A
Reheat stop valve sticks open	2.91E-07	A
Control valve sticks open	7.27E-06	B
Emergency trip fluid line (common to governor and interceptor valve) is clogged	6.97E-08	A
20/OPC solenoid valve failure	1.67E-06	C

Notes:

- A Original failure data from WCAP-11525 Rev.0.
- B Current data base for BB-296 nuclear steam chest valves. The current failure data consists of 24 incidents of sticking in 754 valve operating years. This data is currently under further review and documentation in conjunction with the Westinghouse program for tracking turbine valve failure rates.
- C Utilizes original WCAP-11525 valve operating years (4620 years) but assumes 50 incidents for the calculation of the failure rate for failure to close.

TABLE 2

Probabilities of Turbine Missile Generation
Affected by Interceptor Valve (IV) and Reheat Stop Valve (RSV) Failure

IV & RSV Test Interval	P(A)	P(M/A) 120% Overspeed	P(B)	P(M/B) 132% Overspeed	P(T) = P(A)*P(M/A)+P(B)*P(M/B)
3 MO	1.12E-02	3.60E-05	1.24E-06	1.35E-02	4.20E-07
12 MO	1.14E-02	3.60E-05	9.81E-06	1.35E-02	5.43E-07
18 MO	1.15E-02	3.60E-05	1.96E-05	1.35E-02	6.79E-07

Notes:

- P(T) Probability of turbine missile ejection given that system separation occurs. These probabilities are multiplied by the average annual frequency of system separation to obtain annual probabilities of turbine missile ejection.
- P(A) Probability of design overspeed.
- P(B) Probability of intermediate overspeed.
- P(M/A) Conditional probability of missile ejection given that design overspeed occurs.
- P(M/B) Conditional probability of missile ejection given that intermediate overspeed occurs.

KEY DATA

L.P. Rotor Operating Time (years/hours)	Conditional Probabilities of Missile Ejection			
	Beaver Valley 1		Beaver Valley 2	
	P(M/A)	P(M/B)	P(M/A)	P(M/B)
3/26280	1.13E-06	1.72E-03	4.23E-08	1.90E-04
5/43800 *	3.60E-05 *	1.35E-02 *	2.69E-06	2.47E-03
7/61320	2.52E-04	3.85E-02	2.96E-05	9.71E-03

(*) The calculation of P(T) above utilizes the Unit 1 conditional probability data. The operating time of the L.P. rotors is assumed to not exceed 5 years or 43,800 hours between inspections. The 5 year values have been used in the calculation above.

TABLE 3

Importance Factors of Dominant Faults Contributing
to Design and Intermediate Overspeed probabilities

IV & RSV Test Interval	Importance Factors	
	Design Overspeed	Intermediate Overspeed
3 MO	A(94.68) D(4.09) E(0.65)	B(85.36) D(55.34) C(38.40)
12 MO	A(93.28) D(4.03) E(2.04)	B(94.56) C(70.68) D(25.26)
18 MO	A(92.32) D(3.99) E(2.94)	B(95.68) C(77.84) D(18.66)

Notes:

- Importance factors are determined by summing the importances of all cusets in which the fault appears.

- The letters A through G correspond to the following basic faults:

  - A Control valve (CV) sticks open.
  - B Reheat stop valve (RSV) sticks open.
  - C Interceptor valve (IV) sticks open.
  - D Emergency trip fluid line (common to governor and interceptor valve) is clogged.
  - E Two interceptor valves stick open due to common cause.
  - F Dump valve/RSV - sticks closed.
  - G Dump valve/IV - sticks closed.